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Technology Integration Enhancing Science: Things Take Time Revisited

A revisit of a long-term professional development effort to imbed technology into the K-8 curriculum suggests that lasting changes such as retention of effective existing practices and pedagogical security result when teachers are given sufficient time and duration to carry out the innovation.

Project TIES (Technology Integration Enhancing Science), a four-year K-8 Technology Literacy Challenge project, combined technology as a tool for teaching and learning with earth and environmental science education. This project provided teachers in two North Carolina school systems with professional development as well as technology equipment and materials during the project years, 1998-2002. These resources enabled teachers to make the transition from traditional classroom methodologies to the use of technology as an imbedded and integral part of teaching and learning.

In the TIES project, teachers participated in professional development involving science content, the inquiry process, student-centered projects, and the use of technology as a tool for teaching and learning. Over the course of the project, many TIES teachers assumed leadership roles within their school systems and in state professional organizations, thereby assuring that the expertise and leadership needed to sustain the project for four years resided within the school. One of the goals of the project was to sustain the appropriate use of technologies in classrooms after the project was terminated. The authors were interested in whether the leadership had remained in place and whether these teacher leaders had been able to maintain their gains four years after funding for the project ended. The authors visited the school systems in the original project ending in 2002 again in 2006 to see if this goal of sustainability of the project had been met as well as to see what changes may have occurred in the use of technologies in classrooms since the completion of their original work.

TIES Project schools represent a diverse middle grades student population with respect to ethnicity and economic background and are located in suburban and rural communities.

As the technology era entered the classrooms of the 1990's, it became clear that significant professional development was needed to help teachers understand how to incorporate various technologies as an authentic part of teaching and learning. To help meet this need, the Technology Literacy Challenge Fund (TLCF) was established as part of the Elementary and Secondary Education Act (ESEA). The purpose of the TLCF program was to provide assistance to states and districts to support the integration of technology into school curricula with the goal of improving teaching and learning and enabling all students to become technologically literate. As a result of this ESEA legislation, Project TIES became a reality; and a four-year saga of change and innovation began. [See Shane and Wojnowski article in Science Educator, 14 (1).]

Things Take Time

Change is not easy. For long-lasting pedagogical change to occur, teachers must be afforded the opportunity to learn new teaching methodologies, incorporate those methodologies into their classroom practices, modify any practices that do not work for them, and retest the modifications. "It is clear that, for science and mathematics professional development to be effective, experiences for teachers must occur over time, provide ample time for in-depth investigations and reflection, and incorporate opportunities for continuous learning….[T]he idea of building new understandings through active engagement in a variety of experiences over time, and doing

so with others in supportive learning environments, is critical for effective professional development" (Loucks-Horsley, S., Love, N., Stiles, K.E., Mundry, S., and Hewson, P.W., 2003, p. 81-82). Although the project was nearing completion as this caveat was published, Project TIES reflected this precept. TIES allowed teachers the time to assimilate new pedagogies and implement them in their classrooms.

For this particular technology-based project, it is accurate to add the admonition that "Things Take Materials." The intention was to provide sufficient resources for teachers to make the transition from traditional practice to classrooms where science and technology were imbedded and integral parts of teaching and learning. This was accomplished through a two-pronged approach. First, make the technology equipment available to teachers in sufficient quantity for easy student access within the classroom setting. Second, provide for acquisition of the concomitant abilities needed to use the technology in an appropriate and authentic manner. This approach permitted students and teachers to use technology on a regular and frequent basis and allowed for integrated, project-based instruction. The combination of new knowledge and behaviors as a result of professional development, combined with the needed equipment, helped to provide profound and lasting change.

Project Description

The overarching goal of the TIES Project was to produce a successful, innovative, and replicable model for inquiry- and project-based instruction that used technology to integrate science with other curricula. To attain this goal, teachers developed long-term inquiry-based science projects appropriate for their elementary and middle grades students. Underlying these projects, as well as other classroom instruction, was the seamless blending of technology with science content and project-based instruction. The ensuing professional development not only incorporated project-designed activities, but also a wide array of nationally recognized curriculum materials and activities. The National Science Education Standards were issued at about the same time and became an integral part of the project as well. These programmatic components were phased in over the project's first three years, with full implementation achieved in Year 4.

Project TIES had these objectives:

- provide professional development in:
  - technologies in the context of authentic projects
  - the Internet as a tool to support classroom learning
  - strategies and techniques for integrating technologyinto the curriculum
  - science content for K-8 teachers
- acquire adequate technology hardware and software for partner schools to insure student access
- provide opportunities for TIES participants to learn to utilize their school grounds to enhance their instruction in the context of the science curriculum and technology tools
- provide opportunities for TIES leaders to share their expertise with new TIES teachers, as well as other teachers in their schools
- form a collaboration of partner schools to enhance and support each other

A continuing part of the project was the attainment of assured sustainability for the model. This priority was accomplished by way of five strategies. First, TIES implemented a process of collaborative team efforts utilizing the leadership of experienced TIES teachers. Year-1 and Year-2 teachers became mentors for teachers who entered the project in Year 3. Second, experienced teachers assumed leadership roles as they participated in providing professional development sessions in Years 3 and 4. Third, the technology equipment was housed in teachers' classrooms. Fourth, teams of TIES teachers disseminated knowledge gained and lessons learned from the project as they presented TIES at science and technology conferences and at parent and faculty meetings. Finally, participating schools included TIES in their school-based budgets. This article revisits the success of these five long-term sustainability strategies four years after completion of the funding phase of the project.

Collaborations

The TIES Project was built on the strong collaborations of four schools in two school systems, the Center for Mathematics and Science Education in the University of North Carolina at Chapel Hill (CMSE), the North Carolina Department of the Environment and Natural Resources (DENR), LEARN NC (a statewide technology network), the North Carolina Department of Parks and Recreation, the Eisenhower Consortium at SERVE, and the GLOBE Program. In addition, an external evaluator was recruited to help determine the extent to which the ob-

jectives were achieved. Interestingly, when TIES was revisited after four years, the authors found that although the Eisenhower Consortium is no longer an active entity, the schools and the remaining partners continue to be engaged.

TIES Project schools represent a diverse middle grades student population with respect to ethnicity and economic background and are located in suburban and rural communities. The CMSE brought strong leadership capabilities in grant administration and professional development, as well as technical guidance in developing and implementing educational models. The DENR brought expertise in assessing and understanding the environmental resources of TIES school sites. LEARN NC, a statewide network of educators using Internet technologies, provided teaching resources, lesson plans keyed to the North Carolina Standard Course of Study, and an online outlet that allowed TIES teachers to share their expertise with other educators.

Implementation

Technology can be a powerful entity in classroom instruction when adequate resources are seamlessly incorporated into instructional approaches and strategies. One way to accomplish this is to provide teachers and students with a vehicle for instruction that brings applications to the world beyond the classroom. To implement these real-world projects successfully, teachers must develop skills in integrated instructional strategies, have exposure and experience with specific projects, and be proficient in the appropriate use of technology as a tool for instruction and learning. Administrative support and participation is crucial. Significant commitments of personnel, financial resources, and time are required for a single school to make improvements in these arenas. The need for collaboration is important so teachers, struggling for time to make improvements in their individual classrooms, do not waste time reinventing the wheel.

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To build and apply skills for using available infrastructure effectively, each year TIES classroom teachers, project support staff, and administrators participated in ten days of professional development, including two days at professional conferences. TIES professional development introduced authoring tools, word processing, databases, spreadsheets, and the effective use of the Internet. It also provided hands-on experiences for the understanding of science content –especially in the area of earth science, which blended well with the TIES "outdoors as a classroom" focus.

TIES teams implemented projects based on content and integrated instructional strategies developed during professional development sessions in their own classrooms. This implementation strengthened team building, leadership skills, and mentoring opportunities for TIES teachers and administrators. In TIES, the power of technology merged with a constructivist pedagogy in student-centered, project-based classrooms.

To support both curriculum and standards requirements, TIES project development used the following instructional aproaches.

Constructivist, Student-Centered Learning: Students learn best when they construct their own knowledge, based on multiple experiences with a concept or skill. Through active, hands-on experiences, they correct their misconceptions, extend what they know, and connect their knowledge to other concepts they understand. Student motivation is enhanced when students pursue answers to questions they have developed.

Collaborative Learning: Most students like to work with their peers and learn more from doing so. Working collaboratively is a required workplace skill for the Information Age. Many everyday activities are collaborative, with students working in small groups to solve a problem.

Authentic Learning: Students learn best when their learning is not artificial —when activities are authentic and connected to the world outside the classroom.

Student as Worker, Teacher as Facilitator: A teacher serves as a facilitator to student learning by arranging the environment so that students will ask important questions and discover ways to answer them.

Sustainability. There were two types of sustainability connected to this project: 1) intra-school sustainability within the school(s) after external funding was expended; and 2) inter-school sustainability attached to projects that served as models to be transferred to and used by other

schools and districts. Follow-up questions concentrated on intra-school sustainability.

Intra-school sustainability requires having key elements of materials, equipment, personnel, and leadership in place in a school(s) so a project can continue after funding expires—to have a "life of its own," so to speak. Continued financial support to update equipment and replenish consumable materials is usually necessary as well.

When the authors revisited TIES, they found the leadership and personnel in place and more than willing to sustain and expand the gains made during the TIES project. The funding necessary to replace, update and/or repair equipment and to buy current more advanced technologies has been provided in one TIES system, but has been significantly more limited in the other. Disparities in levels of use of technologies in classrooms that were not evident in 2002 are very evident in 2006.

Great efforts were made with Project TIES to ensure it had the support needed to continue in current schools long after the conclusion of the grant period. Hardware and software were placed in classrooms, and professional development was provided to enable teachers to utilize the technology in an effective manner. In addition, extensive professional development was provided to enable participants to understand how to implement inquiry- and project-based instruction using technology as a tool. Returning TIES teachers emerged as leaders and provided on-going professional development to others in their schools and districts. Local school district budgets were modified to accommodate updates and repairs of project hardware and software.

When the authors revisited the TIES schools four years after the cessation of external funding, they found only three of the original Year 1 teachers still in the classroom in the original schools. Most had moved into administrative positions, retired, or moved away. Interestingly, seven of the teachers who entered in Year 2 and ten who entered in Year 3 were still in the classroom. This means that of the 47 original participants, twenty remained in the classroom four years later. In addition, the building-level technology specialist and science specialist in one school and technology director in another school system, all of whom were instrumental to the original development and implementation of TIES, were still in place.

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When the grant period terminated, partnerships to enhance the grant had been put in place and continued to influence the schools. The project schools committed financial resources to support the project, and plans were put in place for continued funding of additional teachers and classrooms at each school. Experienced TIES teachers were poised to provide continued leadership at their schools. They had shown their leadership by being mentors to new TIES teachers, presenting at conferences, and by developing and presenting technology seminars. Four years later, TIES teachers continued as the technology proponents and leaders within their schools.

Obstacles

Each year, one of the most significant and challenging barriers reported by the project team was a difficulty inherent to any change effort—aversion to change or fear of the unknown. The change from a traditional to a technology-based pedagogical approach is very dramatic and met with resistance in some classrooms. Overcoming that resistance through a slow and on-going change process and reaching the levels of enthusiasm eventually seen in TIES classrooms are certainly two of the most important accomplishments of the project.

That same enthusiasm remained evident four years after the official end of the project. Teachers and administrators in all three TIES schools in both of the original school systems met with the authors, participated in focus groups, provided individual interviews and sent in surveys indicating the current levels of use of technology in their classrooms. All were very forthcoming and presented their current situations honestly and without embellishment. Funding for continued project-based instruction using technology was evident in one system and the lack of sufficient funding was just as obvious in the other. The disparity in funding is the result of differences in local tax bases and academic funding priorities. Teachers in both systems were enthusiastic and quick to tout their successes. They were just as quick to point out deficiencies in funding and technologies that have materialized over the past four years.

Successes

At the beginning of each year of the four years of TIES, teachers set goals and objectives, planned their projects, and proceeded to develop and implement them with the assistance of project staff. Each year, all TIES teachers met the objective of creating hands-on, technology-based projects within their classrooms. In addition, as the project progressed, TIES teachers became instructional leaders who took on responsibility for professional development and mentoring. TIES teachers who have remained in the systems have continued in those roles. Other successes that emerged from the evaluation of the project included positive attitudinal changes toward the objectives of the project.

Those positive attitudes remained very much in evidence as the teachers talked with the authors both individually and in focus group settings. The Levels of Use surveys (see Appendix 1) that participants completed indicated that all participants continue to use technology at least at the refinement level indicating that they continue to make changes in their use of technology in their classrooms to increase technology outcome measures. This level of use is quite remarkable given the equipment, materials and funding constraints under which some of the respondents are laboring.

At the close of the project, schools had strong technology and science resource help systems in place, including TIES mentors from previous years. In spite of time issues, participants who were in the project during the first two years were very helpful to the new project participants both in the technical aspects of how to use equipment and in the pedagogical aspects of using technology as a tool for effective instruction. Returning teachers were very willing to share classroom management techniques with teachers struggling to adapt their classrooms to a new mode of instruction. These returning teachers now work as peer coaches rather than mentors, but the camaraderie and willingness to help and to share expertise that was seen early on in the project is still in evidence.

Results

The overarching goal of the TIES Project was to produce a successful, creative, and replicable model for inquiry- and project-based instruction that used technology to integrate science and other curricula. Quantitatively, we saw an increase in competency rankings in technology knowledge and skills, as measured by a TIES Technology Expertise/Comfort Survey and on the Levels of Use of Technology in the Classroom scale (adapted from the CBAM research, 1987). Other evaluation strategies included site visits, workshop observations, interviews with project personnel, interviews with participants, and comment cards reflecting attitudinal changes from participants. Outcomes anecdotally reported by teachers included shifts in their beliefs and actions from instructionism to constructivism.

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The Levels of Use of Technology in the Classroom self-report scale (Appendix 1, adapted from the CBAM research, 1987) was administered to all participants in the third and fourth years of the project and again in the follow-up phase. Initially, a clear distinction could be made between the levels of use of participants new to the project and those who had been with TIES for one or two years prior to the administration of the instrument. While new participants reported a wide range of levels of use, beginning at Level 0 (Nonuse) and continuing upward through Level IV (Refinement), no returning participant reported a level of use below Level III (Mechanical Use). Also of interest is the rapid movement of Year 3 participants up the Levels of Use scale, as compared to a more gradual movement for teachers who began the project in the first two years. Based on participant comments to a series of open-ended questions and on interview responses, this was presumed to be a result of mentoring provided by Year 1 and 2 teachers, as well as indirect exposure to the project before actually becoming a part of it. Year 4 participants showed limited growth; however, they were only in the project for one year, which is too short a period to allow for valid, reasonable conclusions to be drawn at that time. After five years, all of the participants reported use at Level IV (Refinement) or above. There was no discernible difference in Levels of Use among participants who entered the program in different years and all who were able to be reached were still actively engaged in the use of technology as an integral part of their work.

The project team noted some unanticipated beneficial outcomes. The comment cards used for formative

evaluation indicated that the internal mentoring, support, and the coaching network were much stronger than proposers initially anticipated. Additionally, teachers reported that students wrote about their TIES projects with much less prodding than in traditional writing assignments.

The project team was also surprised, not that teacher attitudinal changes occurred, but by the extent of those changes, as evidenced in the comment cards. The magnitude of observed and anecdotally reported changes from a didactic to a student-centered teaching environment was much greater than proposers anticipated at the outset. Much to the delight of the proposers, these initial attitudinal changes as noted at the end of the project period, based on interviews and surveys, were still in evidence four years later.

Implications

"Fundamental beliefs are formed over time through active engagement with ideas, understandings, and real-life experiences….Deep change occurs only when beliefs are restructured through new understandings and experimentation with new behaviors" (Loucks-Horsley, S., et al., 2003, p. 49). For change to occur, things take time. This study exemplifies these beliefs. Initially, teachers who participated in the project for three or four years showed greater changes than those with only one or two years experience. Only participants who were in the project for more than two years reached Level V (Integration) or VI (Renewal) on the *Levels of Use of Technology* scale; not all veteran participants ever rose above Level IV (Refinement). After five years, all participants reported levels of use at Level IV or above, and no discernible difference was noted among participants by year of entry. The change literature, as well as our own experiences with this project, has led us to conclude that significant behavior changes require at least three to four years of implementation and on-going support to become institutionalized within the classroom and that institutionalization is retained as a part of regular classroom practice long after the end of the funding period.

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Appendix 1

CBAM Levels of Use of Technology in the Classroom

Name____

Year 1 (returning) _______

Year 2 (returning) _______

Year 3 (returning) _______

Year 4 (new) _______

Please circle the number that best reflects your current level of use of technology in your classroom.

Levels of Use	Behavioral Indices of Level
VI Renewal	I am seeking more effective alternatives to the already routinely established use of technology in my classroom.
V Integration	I am making deliberate efforts to help others to use technology in their classrooms.
IV Refinement	I am making changes in my use of technology in my classroom to increase outcomes.
III Mechanical Use	I am using technology in my classroom, but it is not always coordinated to my course of study.
II Preparation	I am preparing to use technology in my classroom.
I Orientation	I am seeking information on using technology in my classroom.
0 Nonuse	I am not taking any action in regard to using technology in my classroom.

(Adapted from the CBAM Project, Research and Development Center for Teacher Education, The University of Texas, 1987.)